Manta TRUST

Maldives Manta Conservation Programme

BAA ATOLL | ANNUAL REPORT 2024

Conservation through research, education, and collaboration

- The Manta Trust

MALDIVES MANTA CONSERVATION PROGRAMME

WHO ARE THE MANTA TRUST?

The Manta Trust is a UK and US-registered charity, formed in 2011 to co-ordinate global research and conservation efforts around manta rays. Our vision is a world where manta rays and their relatives thrive within a globally healthy marine ecosystem.

The Manta Trust takes a multidisciplinary approach to conservation. We focus on conducting robust research to inform important marine management decisions. With a network of over 20 projects worldwide, we specialise in collaborating with multiple parties to drive conservation as a collective; from NGOs and governments, to businesses and local communities. Finally, we place considerable effort into raising awareness of the threats facing mantas, and educating people about the solutions needed to conserve these animals and the wider underwater world.

Conservation through research, education and collaboration; an approach that will allow the Manta Trust to deliver a globally sustainable future for manta rays, their relatives, and the wider marine environment.

MALDIVES MANTA CONSERVATION PROGRAMME

Formed in 2005, the Maldives Manta Conservation Programme (MMCP), formerly the Maldivian Manta Ray Project (MMRP), is the founding project of the Manta Trust, and has been a Maldives registered charity since 2022. It consists of a country-wide network of dive instructors, biologists, communities and tourism operators, with more than a dozen MMCP staff based across a handful of atolls, on both resort islands and local islands.

The MMCP collects data around the country's manta population, its movements, and how the environment and tourism / human interactions affect them. Since its inception, the MMCP has identified over 6,000 different individual reef manta rays, from more than 80,000 photo-ID sightings. This makes the Maldives manta population the largest, and one of the most intensively studied populations in the world. The MMCP has also identified more than 1,000 different individual oceanic manta rays.

Not only does this invaluable information improve our understanding of these animals, but it informs their ongoing management and protection both in the Maldives, and around the world.

THE CONSERVATION CHALLENGE

In the last two decades, manta and mobula rays have faced increasing threats from both targeted and bycatch fisheries, due in part to a growing trade in Asia for their gill plates. The gill plates are what these rays use to filter zooplankton from the water. In Traditional Asian Medicine, it is believed these gill plates will filter the human body of a variety of ailments when consumed in tonic. There is no scientific evidence to support this claim.

Unregulated and badly managed tourism is also negatively affecting manta rays, while climate breakdown, reef degradation and pollution is reducing the manta's food supply and suitable habitat.

Manta and mobula rays are particularly vulnerable because of their aggregating behaviour and conservative life-history; they grow slowly, mature late in life, and give birth to few offspring. These traits make it very easy to wipe out entire populations in a relatively short period of time. With protection in place, populations are still slow to recover.

EXECUTIVE SUMMARY

Since 2007, the Maldives reef manta ray (*Mobula alfredi*) population in Baa Atoll has been continuously monitored by the Maldives Manta Conservation Programme (MMCP). Reef manta rays and whale sharks (*Rhincodon typus*) frequent the eastern side of Baa Atoll each year to feed on the abundant zooplankton prey that results from the productive Southwest (SW) Monsoon conditions. Baa Atoll is internationally renowned as being one the most reliable places to see and swim with these planktivorous megafauna.

Details on the ecology, population dynamics, and movements of Baa Atoll's reef manta rays throughout 2024 are provided in this report, with the majority of presented results focused on data collected during the intensive survey period from May through November. Furthermore, this report discusses various tourism and education activities conducted within Baa Atoll during 2024.

The MMCP, with outside contributions, documented 1,391 reef manta ray surveys on 236 days in 2024. The MMCP conducted 1,205 of these surveys over 181 days, with outside parties contributing 186 surveys on an additional 55 survey days. Of the 236 survey days in 2024, 180 fell between the 1st of May and the 30th of November. Key findings of the MMCP in Baa Atoll during 2024 include a total of 4,592 sightings of 663 individual manta rays. Of these individuals, each manta ray was observed on average 6.9 times. The mean daily number of reef manta ray sightings between May and November was 25, with a peak in the month of August (*n*=45). A Residency Index (RI) was calculated to gauge the extent of movement amongst those frequenting the region. The RI for 2024 (2.9%) represented a slight decrease from 2023 (3.2%). The total number of sightings (*n*=3,382) and number of individual manta rays (*n*=526) recorded in Hanifaru Bay MPA in 2024 was also lower than in 2023 (sightings, *n*=4,454; individuals, *n*=584).

As of 2024, the population demographics of Baa Atoll constitute 2,556 individuals, of which 1,352 (53%) are female, 1,177 (46%) are male, and 27 (1%) are of unknown sex. Of these Baa Atoll individuals (*n*=2,556), 49% (*n*=1,246) have also been seen in at least one other atoll in the Maldives. Of the 663 individuals observed in 2024, 350 were female and 299 were male.

A total of 226 new reef manta rays were added to the MMCP database from across the Maldives in 2024, bringing the total number of identified individuals in the Maldives to 6,096. Of the new manta rays identified in 2024, 23% (*n*=53) were documented in Baa Atoll, similar to the previous year (2023, *n*=52). Within Baa Atoll, 50 of these new individuals were juveniles.

The number of pregnancies recorded in Baa Atoll alone in 2024 was 13, a decrease from the previous year (2023, n=54). Of the 13 pregnant females observed, 62% (n=8) were recorded in the later stages of gestation (3rd to 4th trimester) when first sighted. A further 8 females were recorded with fresh reproductive wounds but were not recorded as pregnant.

During 2024, the MMCP delivered two Moodhu Madharusaa Marine Education Programmes to students from B. Kihaadhoo School and B. Dhonfanu School. A total of 32 students from Kihaadhoo School completed 50 hours of theory classes and field trips over six months, with students spending 16% more time snorkelling and exhibiting improved marine environmental attitudes, pro-environmental behaviours, and snorkelling confidence post-programme. Subsequently, a condensed three-month programme was completed by 29 students from B. Dhonfanu School, with post-programme surveys showing the students' environmental knowledge improved by 27%. Further to these programmes, the MMCP conducted and attended various education and outreach events throughout the year.

THE BAA ATOLL REGION

Geographically, the Baa Atoll region is comprised of three geographical atolls: South Maalhosmadulu, Fasdhūetherē, and Goidhu (administratively and collectively, Baa Atoll) (Fig. 1). South Maalhosmadulu Atoll is a very large (943 km²) complex atoll, consisting of 60 islands and sandbanks, nine of which are inhabited and another dozen host resorts. The lagoon depth reaches a maximum of 49m and the channels separating the islands along the atoll's outer reef are mostly wide and deep. Fasdhūetherē Atoll is much smaller (134 km²), has only 12 islands/sandbanks separated by wide channels and a shallow lagoon (34 m max.). Goidhu is the smallest of the three geographical atolls (111 km²), with just four well vegetated islands and a few islets and sandbanks, it is considered an oceanic faro. Goidhu Atoll has a shallow lagoon (37m max.) with only one natural channel break in the south of the atoll, resulting in limited water flushing between the inner lagoon and outer reef. All three atolls are part of the northern section of the central Maldives archipelago; Fasdhūetherē lies just 1 km to the north of South Maalhosmadulu and the two atolls are separated by a shallow channel (Kudarikilu Kandu). Goidhu Atoll is located 12 km to the south of South Maalhosmadulu Atoll. Analysis throughout the report refers to this combined area as the Baa Atoll region.

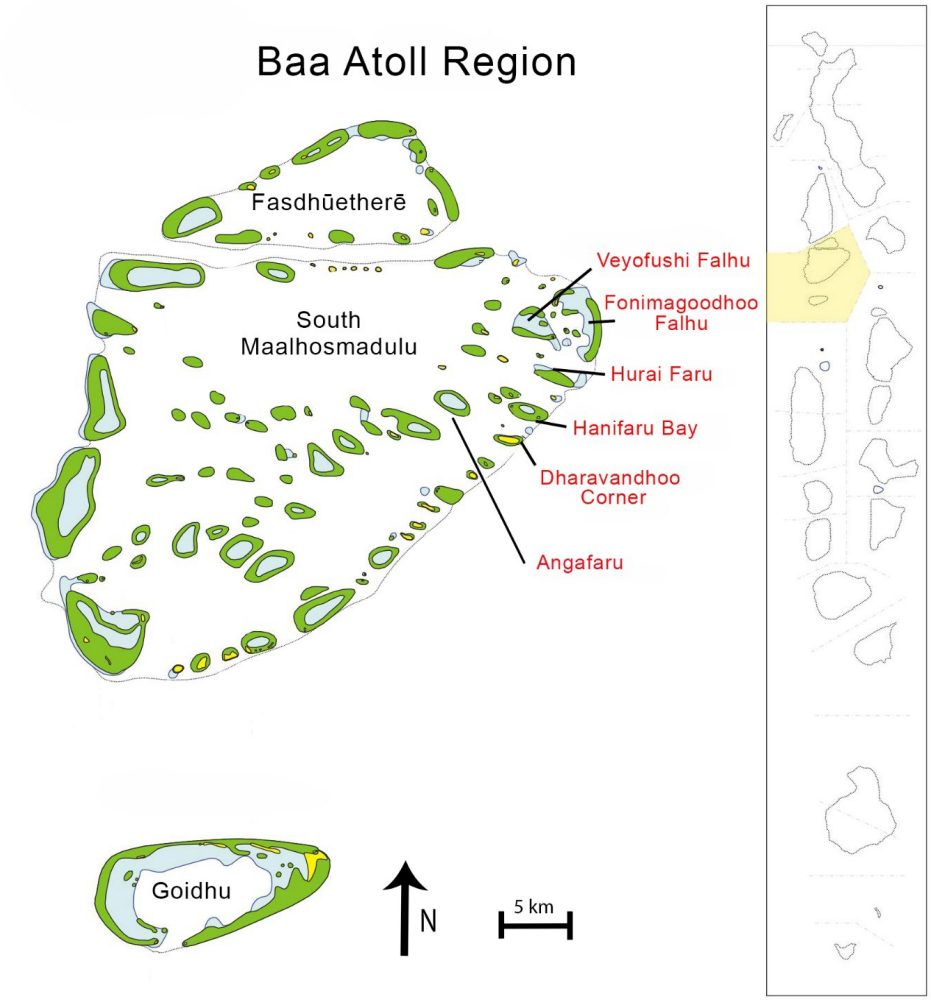
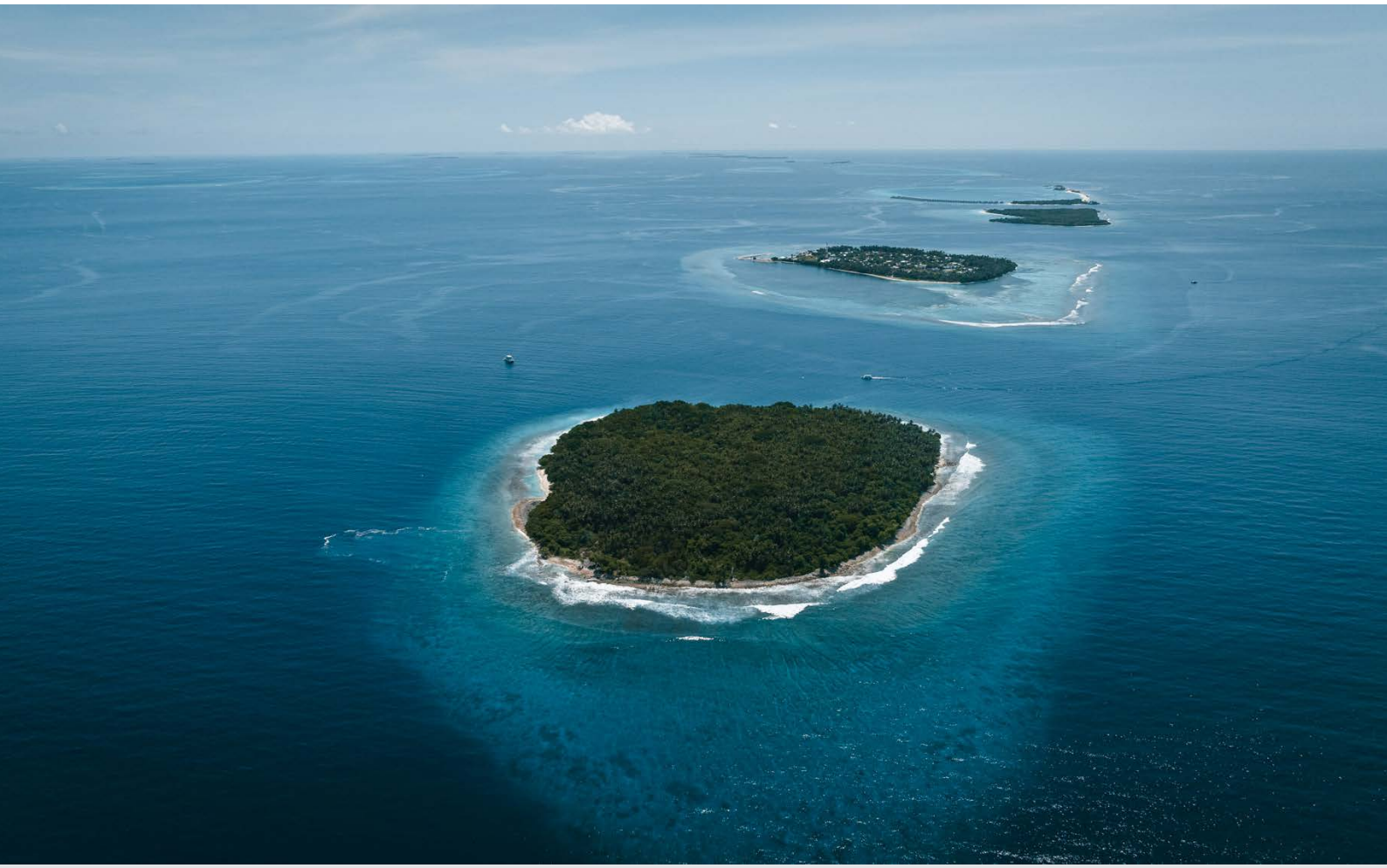


Figure 1: Map of the Baa Atoll region showing the three geographical atolls (in black), six of the key reef manta ray (*Mobula alfredi*) aggregation study sites (in red), and the region in relation to the rest of the Maldives Archipelago (shaded yellow).

UNDERSTANDING THE MONSOONS

Understanding the effects of the Maldives Southwest Monsoon is inherently vital to understanding why Baa Atoll has such an abundance of marine megafauna, such as manta rays and whale sharks. Weather patterns within the Maldives are largely dictated by the South Asian Monsoon. This monsoon has two seasons, characterised by their winds which blow consistently and reverse their direction seasonally. May to October is recognized as *Hulhangu*, while December to March is known as *Iruvai*. *Hulhangu* and *Iruvai* refer to the Southwest (SW) and Northeast (NE) Monsoon respectively. The months of November and April are transitional periods of change between these two distinct seasons. An increase in rain and cloud cover, along with reduced visibility and rough seas is typical of the Southwest Monsoon.

The strong winds created during the Southwest Monsoon generate oceanic currents which flow from the southwest towards the northeast. The Maldives' atolls, rising 2,000 metres from the sea floor, act like a barrier to these currents, displacing the water as it flows through and around the atolls, creating deep-water upwelling. These upwellings bring nutrient rich water to the surface, kick-starting the food-chain and providing plentiful zooplankton prey for filter feeding megafauna such as manta rays and whale sharks. During the Southwest Monsoon, the lunar phases and high wind speeds generate strong currents, which in turn create more upwelling. The daily movement of water through channels into the atolls is driven by these strong currents and tides. The atolls, as well as the reef systems within them, act as plankton funnels and traps that accumulate high densities of planktonic life. Baa Atoll, and specifically Hanifaru Bay, amass vast amounts of zooplankton during the Southwest Monsoon and, therefore, transform into hotspots for large aggregations of zooplanktivorous megafauna.



STUDY PERIOD & SAMPLING METHODOLOGY

The Baa Atoll Project is based at the Four Seasons Resort on the island of Landaa Giraavaru, located in the northeast of Baa Atoll. In 2024, MMCP researchers carried out directed surveys on as many days as the weather conditions allowed between the 5th of May and the 28th of November, in line with the Southwest Monsoon. These intensive surveys were conducted at six key manta aggregation sites, including Hanifaru Bay, and a dozen other sites around the eastern border of Baa Atoll (Fig. 1). The MMCP also collected self-reported data from citizen scientists, which include dive guides, marine biologists, and tourists. These external reports made up the bulk of surveys conducted during the months of the Northeast Monsoon (December to April).

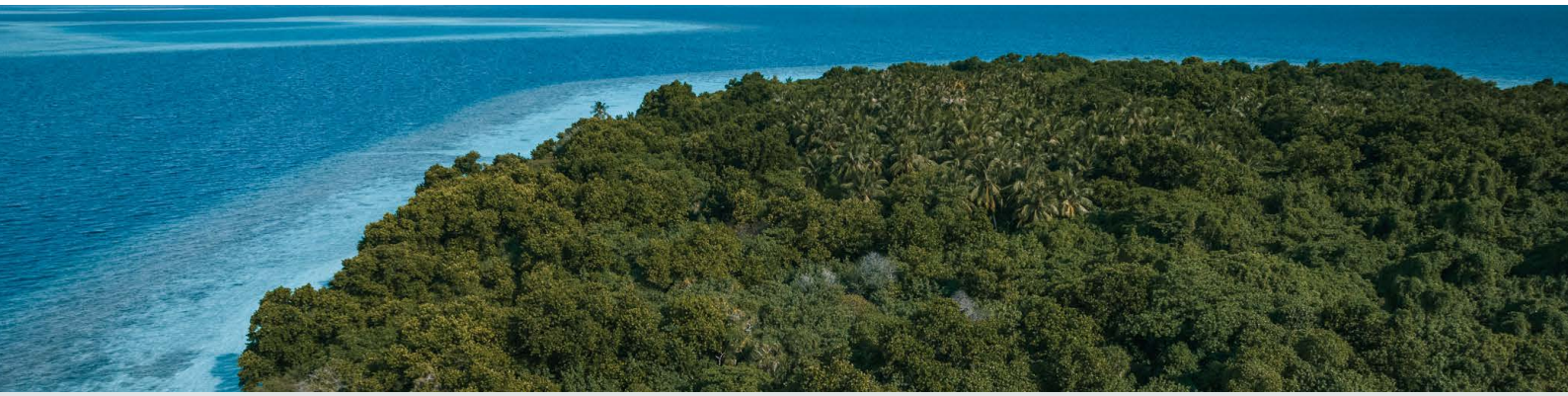
A total of 1,391 manta ray surveys were undertaken in Baa Atoll during 2024 across 236 survey days, or 64% of the total possible days within the year. The MMCP alone conducted 1,205 surveys on 181 days. MMCP surveys were carried out by observers (*n*=1,085), remote underwater video systems (*n*=107), and remote underwater photo systems (*n*=13). External parties contributed an additional 186 surveys across 142 survey days; 55 of these survey days were days when MMCP did not conduct any surveys. During the months of the Southwest Monsoon (May to November), surveys were conducted on 180 days, representing 84% of the total possible survey period of 214 days. Within this period, MMCP conducted 1,199 surveys over 168 days, while external parties contributed an additional 131 surveys across 92 days.

To ensure comparable results, data were standardised where possible to account for changes in sampling effort spatially and temporally. All surveys undertaken by the MMCP team were recorded, whether manta rays were sighted or not. The results presented in this report also include sightings submitted to the MMCP by external parties. All recorded surveys were accounted for when standardising for survey effort for submissions by external parties.

During each survey conducted by the MMCP, location, tourism information, and multiple environmental variables were collected, along with manta ray abundance and behaviours (e.g., feeding, cruising, cleaning, etc.). Individual manta rays were documented in-water by photographing the unique spot pattern on their ventral surface. A sighting is defined as a uniquely identifiable manta ray observed at a particular site on a particular day.

Remote underwater video (RUV) surveys are commonly used in research to monitor specific areas and their use by different marine life whilst humans are absent. These GoPros are placed in underwater housings and anchored to the reef with a dive weight, where they continuously record a cleaning station for up to three hours. Having identified several cleaning stations within Baa Atoll, the MMCP's long-term aim is to increase survey effort at these sites. In 2024, 107 RUV surveys were conducted over 73 survey days.

This is the fifth year that the MMCP has used a remote underwater photo (RUP) system to capture photo-IDs of reef manta rays that gather at cleaning stations. This camera system uses a GoPro that is programmed to take a photo every minute from sunrise (6:00) to sunset (18:00) and is equipped with battery packs that allow for 5 to 7 day deployment periods. Technical difficulties limited the team's use of RUPs in 2024; MMCP conducted 13 surveys over a period of 13 days.



REEF MANTA RAY SIGHTING TRENDS

Baa Atoll Region

In 2024, a total of 4,592 sightings of reef manta rays were recorded in Baa Atoll (Fig. 2), representing a 12.8% decrease in reef manta ray sightings compared to 2023 (*n*=5,268). On average, 19 manta rays were sighted per survey day in 2024 overall, with an average of 25 sighted per survey day during the months of the Southwest Monsoon (May to November). Monthly breakdowns reveal that daily sightings increased in the first half of the season, peaking in August (*n*=45), before declining rapidly in October (*n*=4), and peaking a second time in November (*n*=35) (Fig. 3).

A total of 663 different individual reef manta rays were recorded in Baa Atoll in 2024, which comprises 10.9% of the total recorded Maldives population (*n*=6,096) and represents a slight decrease from 2023 (*n*=672) (Fig. 4). Throughout 2024, 80% of individuals (*n*=531) were observed more than once, and each manta ray was observed 6.9 times on average (Fig. 4). The number of sightings per individual was highest in November, with an average of 2.9 sightings per individual (Fig. 5). The most sighted individuals were MV-MA-2993 (Grebe) and MV-MA-3355 (Anne), both adult females who were each recorded 36 times.

To account for survey effort, a Residency Index (RI) was calculated for each month based on the ratio between the number of days each individual was sighted and the total number of surveyed days (e.g., a RI of 5% means that, on average, each individual was sighted on 5% of the total surveyed days). The RI for 2024 (2.9%) was marginally lower than in 2023 (3.2%) (Fig. 6), potentially indicating a more transient population in 2024 compared to previous year. Monthly breakdowns show that the RI was highest (indicating less transient behaviour) in August (10.4%) and November (10.4%), and lowest in October (5.5%) (Fig. 7).

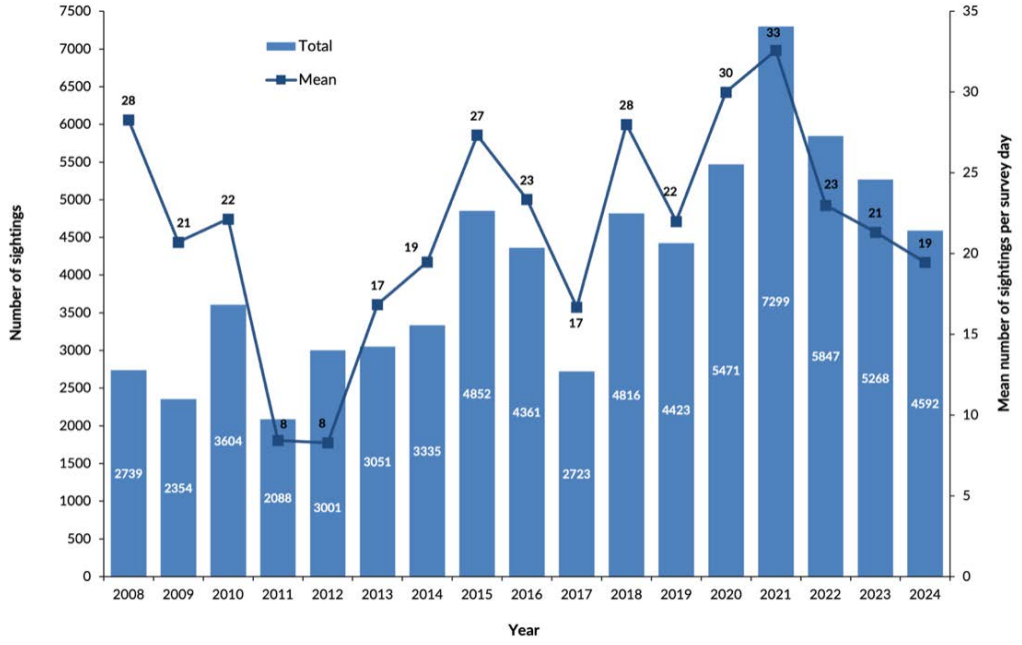


Figure 2: Annual sightings of reef manta rays (*Mobula alfredi*) in Baa Atoll Region from 2008 to 2024, and the mean number of sightings per survey day.

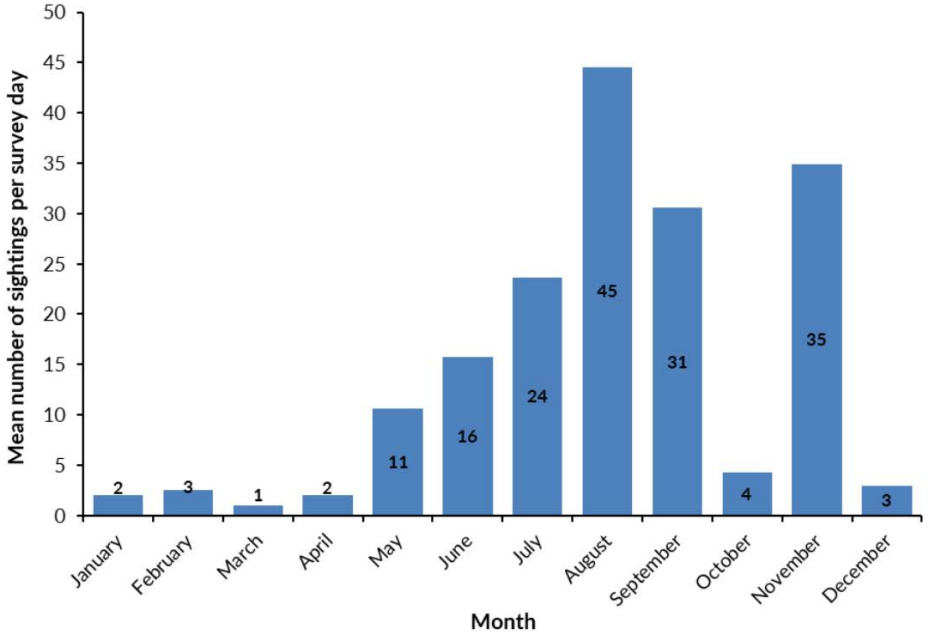


Figure 3: Monthly breakdown of reef manta ray (*Mobula alfredi*) sightings per survey day in Baa Atoll Region during 2024.

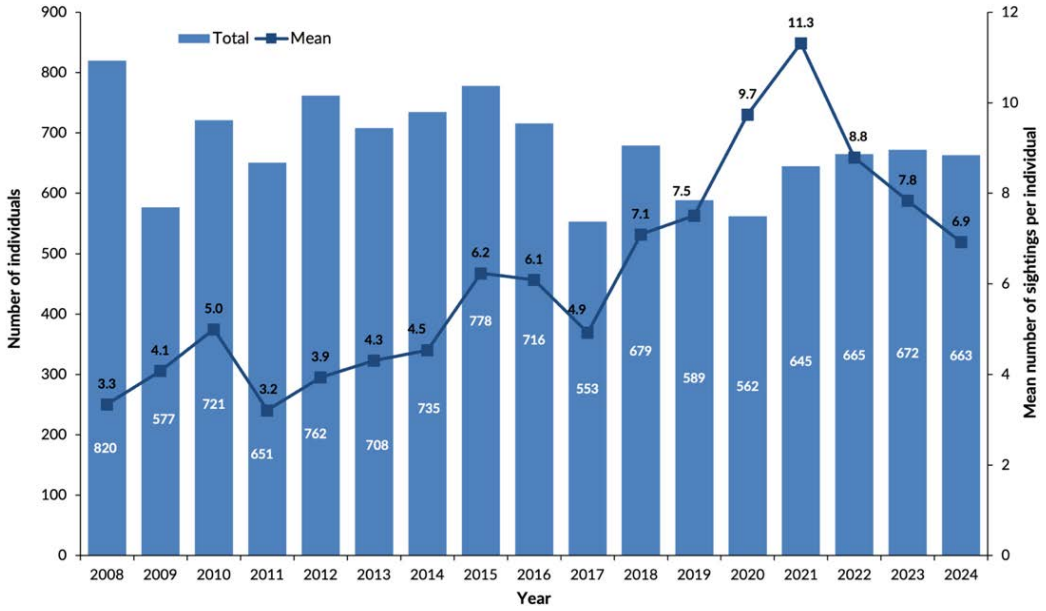


Figure 4: Annual number of individual reef manta rays (*Mobula alfredi*) sighted in the Baa Atoll Region from 2008 to 2024, and the mean number of sightings per individual.

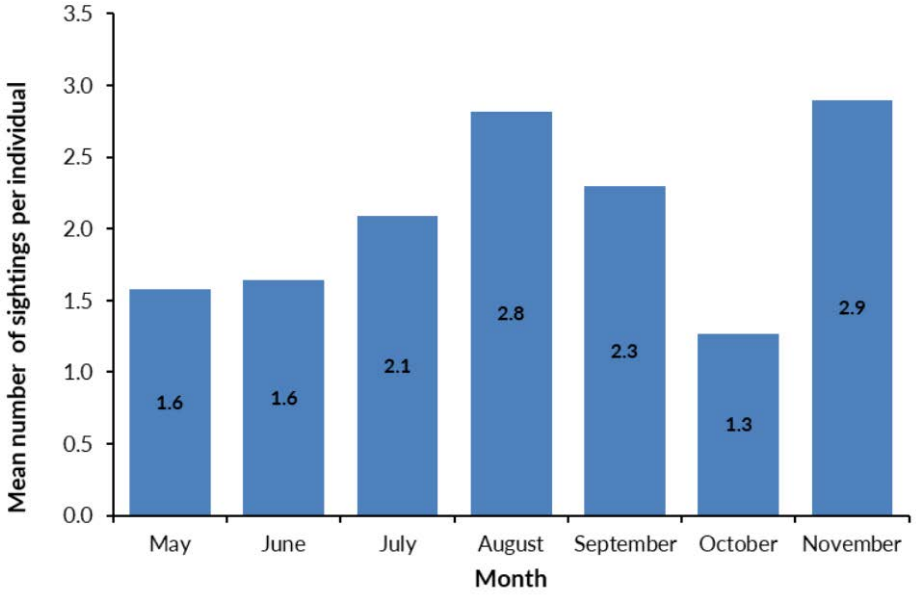


Figure 5: Mean number of sightings per reef manta ray (*Mobula alfredi*) during each month of intensive surveying in 2024.

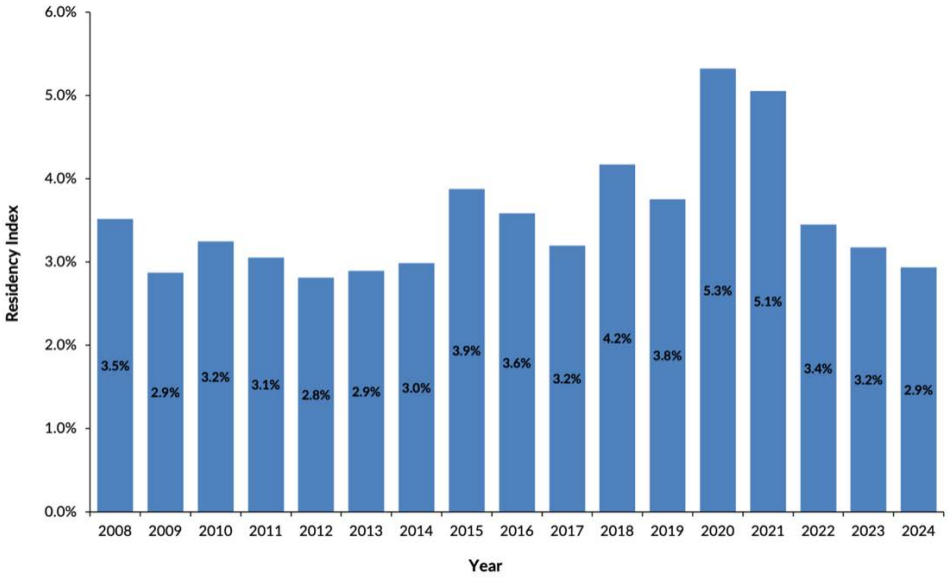


Figure 6: Annual Residency Index (RI) of the reef manta rays (*Mobula alfredi*) in Baa Atoll from 2008 to 2024. RI is calculated as the average of each individuals' residency score (= number of times sighted annually divided by the total number of survey days).

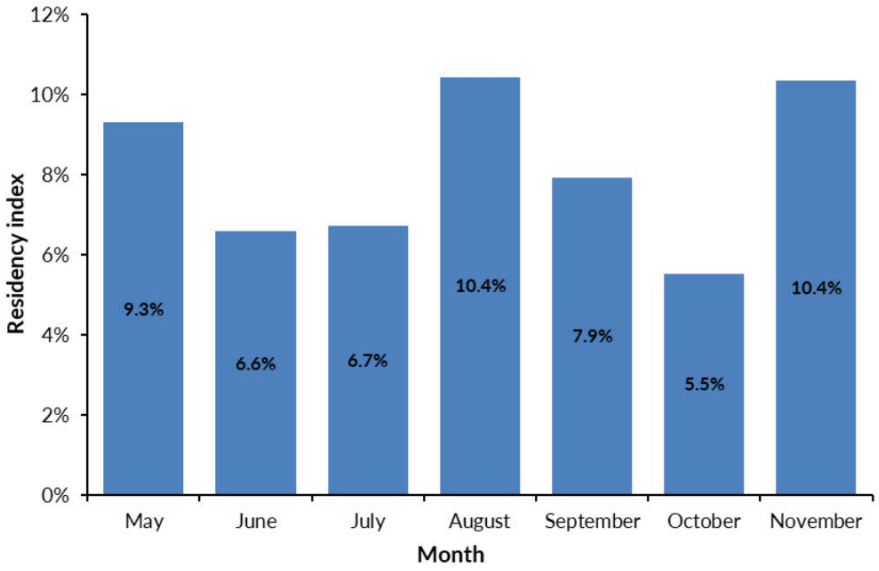


Figure 7: Residency Index of reef manta rays (*Mobula alfredi*) for each month of intensive surveying in Baa Atoll during 2024.

Hanifaru Bay (Marine Protected Area)

In 2024, 3,382 sightings of 526 reef manta rays were recorded in Hanifaru Bay MPA alone (Fig. 8), accounting for 74% of sightings recorded in Baa Atoll overall (*n*=4,592). This figure reiterates the site's importance as critical habitat for the species and further warrants its status as a marine protected area. All of these sightings occurred between May and November, during the Southwest Monsoon. During this period, 25 reef manta rays were sighted per survey day on average, with a peak occurring in August (*n*=47) (Fig. 9).

Each manta ray was sighted 6.4 times on average, and the individual with the highest number of recorded sightings was MV-MA-3355 (Anne) (*n*=34). The 19th of August saw the greatest number of individuals recorded on a single day during the year, with a total of 165 confirmed reef manta rays identified from Hanifaru Bay. August was also the month with the highest number of overall sightings (*n*=944) and individuals (*n*=359) recorded in Hanifaru Bay.

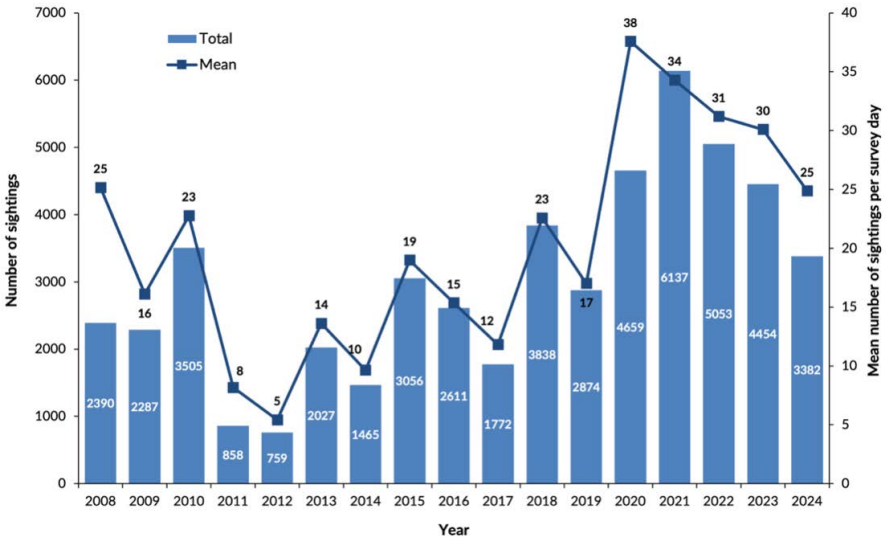


Figure 8: Annual sightings of reef manta rays (*Mobula alfredi*) in Hanifaru Bay from 2008 to 2024, and the mean number of sightings per survey day.

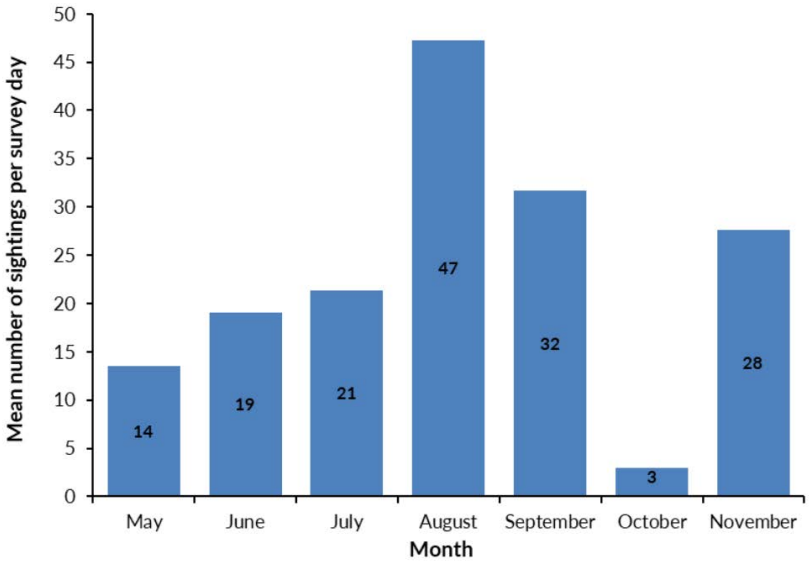


Figure 9: Average number of reef manta ray sightings (*Mobula alfredi*) recorded per survey day inside Hanifaru Bay during each month of intensive surveying in 2024.

Angafaru Area (Marine Protected Area)

The Angafaru MPA includes Angafaru, Angafaru Falhu, Dhonfanu Thila, and Dhigu Thila. In past years (2010 to 2021), the total number of sightings recorded in this area has fluctuated between one and 209, with the highest number of sightings occurring in 2019 (*n*=209) and 2020 (*n*=85) (Fig. 10). In 2024, 33 sightings of 30 individuals were recorded in the Angafaru MPA, of which all but one occurred between May and November. Standardising the data by the number of days this area was surveyed (*n*=68) revealed that sightings per survey day decreased slightly in 2024 (*n*=0.5) compared to the previous year (*n*=0.6) (Fig. 10). Monthly breakdowns reveal the highest average number of sightings per survey day occurred in July (*n*=1.1) (Fig. 11). The highest number of individuals recorded in a single day in the Angafaru MPA occurred on 10th June, when seven individuals were sighted at Dhigu Thila.

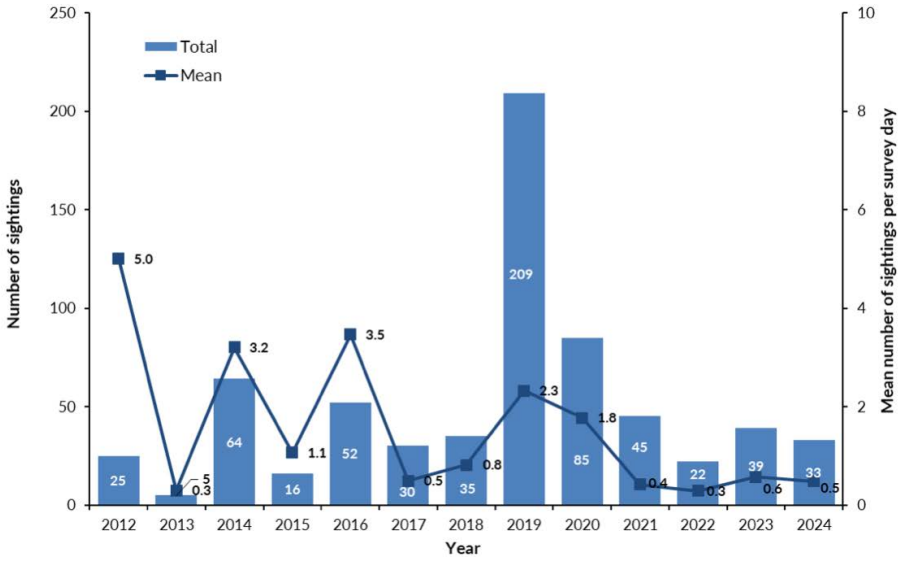


Figure 10: Annual sightings of reef manta rays (*Mobula alfredi*) in the Angafaru MPA from 2012 to 2024, and the mean number of sightings per survey day.

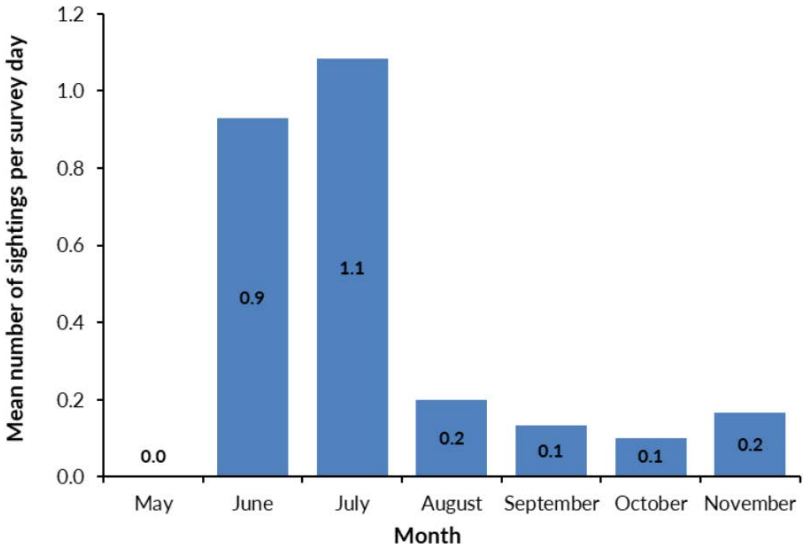


Figure 11: Average number of reef manta ray (*Mobula alfredi*) sightings recorded per survey day in the Angafaru MPA during each month of intensive surveying in 2024.

Weather & Climactic Variation

The MMCP continued to investigate the possible relationship between environmental variables (such as wind speed and direction) and the frequency of reef manta ray sightings. In the years preceding 2024, May (which marks the start of the Southwest Monsoon) typically demonstrates characteristically high wind speeds. In 2024, the average wind speed rose from 12.02 km/h in April to an annual peak of 22.43 km/h in May, with the arrival of the Southwest Monsoon. Average wind speed remained between 14.2 and 21.6 km/h in subsequent months before declining to an annual low of 9.55 km/h in November (Fig. 12). Data from previous years indicate cyclical trends where average manta ray sightings tend to increase one or two months following an increase in average wind speeds. This trend was not observed in 2024, which may be a contributing factor to the decrease in overall manta ray sightings observed (Fig. 12). Data pertaining to the wind speed, direction, and fine scale changes in the weather conditions in the region throughout 2024 were provided to the MMCP by the Maldives Meteorological Service.

It has been previously hypothesised by the MMCP that higher overall wind speed results in more favourable conditions for zooplankton, contributing to the concentration of localised prey patches and attracting manta rays to the region. Across all years, generally, when the annual wind speed increases, so do the average number of manta ray sightings (Fig. 13). The average wind speed recorded in 2024 was 15.6 km/h, higher than in 2023 which had an average wind speed of 14.6 km/h. Despite the increase in wind speed, the overall number of reef manta ray sightings per survey day dropped from 21 in 2023, to 19 in 2024, highlighting that wind speed is by no means the sole contributing factor in predicting manta ray sightings. For example, the number of sightings per survey day in 2020 (n=30) was considerably higher than in 2022 (n=23); yet the average wind speed in 2020 (17.4 km/h) was lower than the average from 2022 (18.4 km/h). Further, while average wind speeds in 2008 and 2011 were similarly low (15.1 km/h and 15.0 km/h, respectively), there was a drastic difference in the mean sightings per survey day (n=32 in 2008, and n=9 in 2011).

Wind directions recorded from the Maldives Meteorological Society's met station (situated at Dharavandhoo Island, Baa Atoll) reveal variability throughout May to November (Fig. 14). Directions were classified into eight main directions combining multidirectional winds into their main category (i.e., NNW winds were classified as N). As expected during the Southwest Monsoon of 2024, westerly and south-westerly winds dominated from May to November, contributing to 27% and 50% of daily average wind direction readings during this time, respectively (Fig. 14). Winds prevailing from the southwest accounted for 77% and 71% of readings in June and July, respectively, preceding higher numbers of manta ray sightings recorded in August and September. Winds prevailing from the west accounted for between 52% and 67% of readings between September and November.

The fluctuation of monsoonal strength, food availability, manta ray sightings and reproductive activity are likely part of a natural cycle which occurs within the Maldives over time. Larger climatic mechanisms, such as the Indian Ocean Dipole (IOD), the Madden-Julian Oscillation (MJO), and the El-Niño Southern Oscillation (ENSO) are likely to be connected to these fluctuations as all have been known to strongly influence currents throughout the atoll and exert control over productivity. All are linked to the increased fluctuations in climate change recorded in the Indian Ocean in recent decades. This may be particularly relevant here as an El-Niño event was documented between October 2023 to May 2024, and is likely to have had some impact on food availability, reef manta ray sightings, and fecundity during 2024. Only on-going and consistent monitoring will elucidate the causal drivers behind these variables, and determine what measures need to be taken to manage them. These observations should be considered seriously because of the negative economic consequences they can have, regardless of cause and ecological ramifications. Disrupted trends in manta sightings can have an impact on the tourism industry, which relies heavily on advertising nearly guaranteed sightings of manta rays at certain times of year at specific sites. Not only will manta ray tourism be directly affected by these trends, but also on a wider scale, they will affect the wider tourism and fishing sectors, which heavily rely upon the ocean's productivity, and therefore the strength of the monsoons.

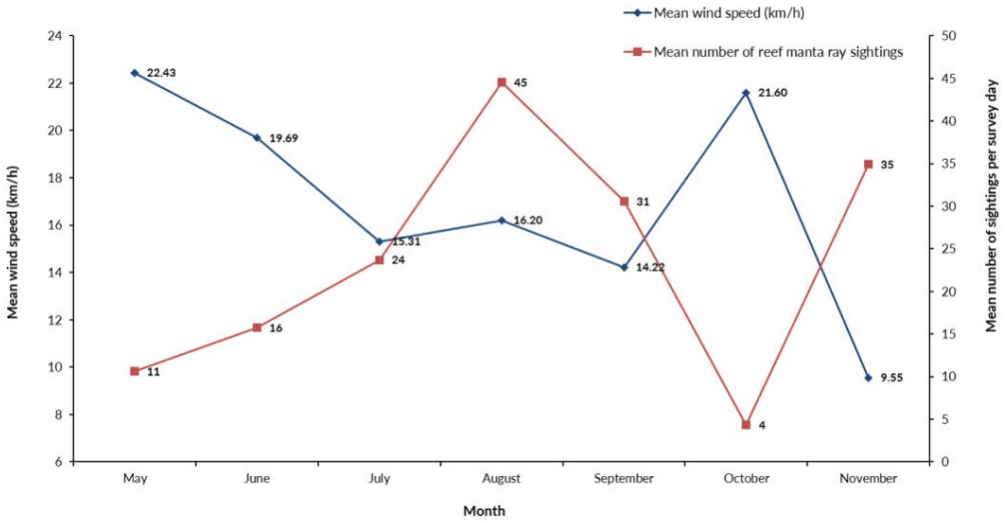


Figure 12: Mean monthly wind speed (km/h) and mean number of reef manta ray (*Mobula alfredi*) sightings per survey day in Baa Atoll (2024).

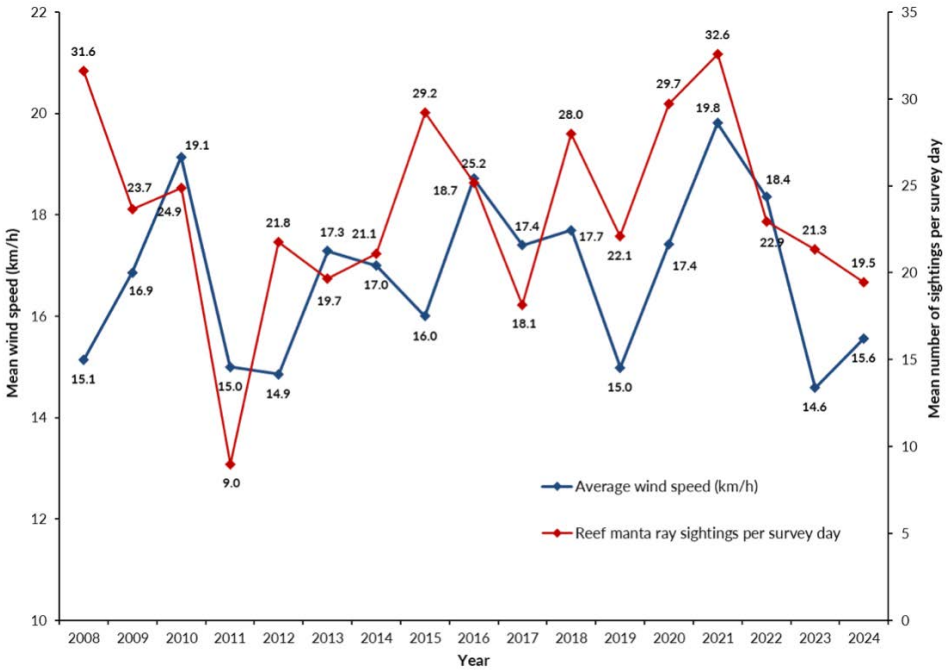


Figure 13: Mean annual wind speed (km/h) and the mean number of reef manta ray (*Mobula alfredi*) sightings per survey day in Baa Atoll from 2008 to 2024.

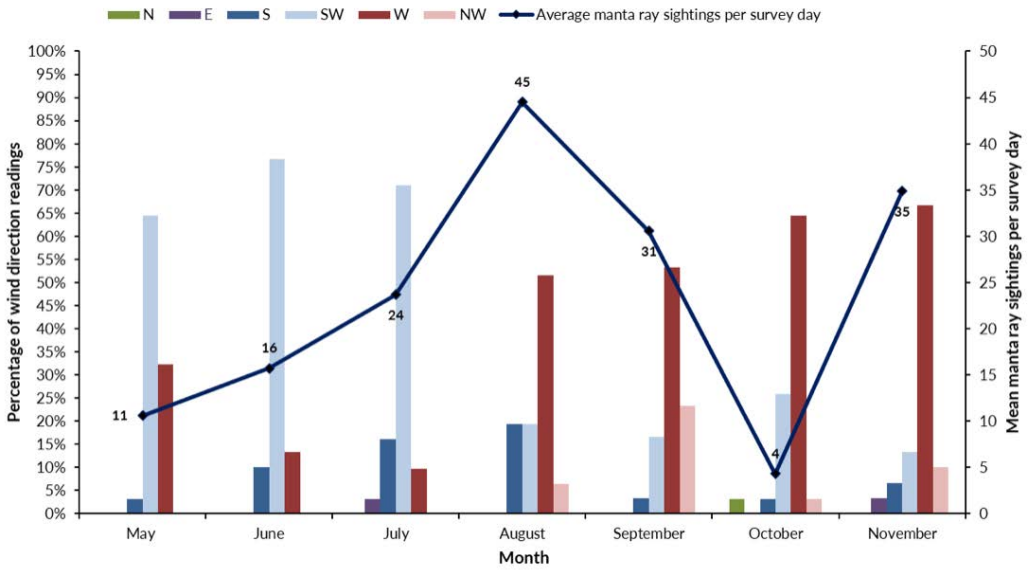


Figure 14: Monthly breakdown of the percentage of wind direction readings from the Maldives Meteorological Society's weather station, and the average number of reef manta ray (*Mobula alfredi*) sightings per survey day in Baa Atoll (2024).

WHALE SHARK SIGHTINGS

Whale sharks often inhabit the same feeding grounds as reef manta rays, and these species are regularly sighted together along shallow reefs throughout the Maldives. In 2024, the MMCP team recorded a total of 28 whale shark sightings in Baa Atoll, a 12% increase from the previous year (2023, *n*=25) (Fig. 15). Of these, researchers collected ID photographs for 71% of sightings (*n*=20), confirming the presence of 15 different individuals in Baa Atoll. Overall, whale shark sightings in Hanifaru Bay accounted for 39% (*n*=11) of the total in 2024.

All but two recorded sightings occurred during the Southwest Monsoon (May to November), and monthly breakdowns revealed a peak in total whale shark sightings (*n*=7) and identified sightings (*n*=6) in July (Fig. 16), with the highest number of different individuals recorded in July and August (*n*=5). Interestingly, the MMCP recorded the highest number of manta ray sightings in August (*n*=1,202), suggesting that the prevailing conditions during July and August were most favourable for these planktivorous species (Fig. 17).

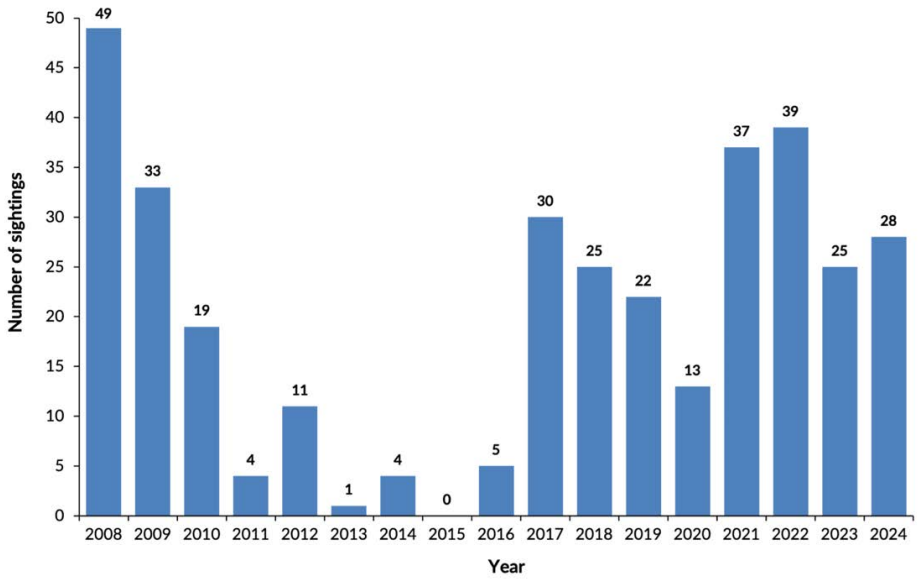


Figure 15: Annual sightings of whale sharks (*Rhincodon typus*) in Baa Atoll from 2008 to 2024.

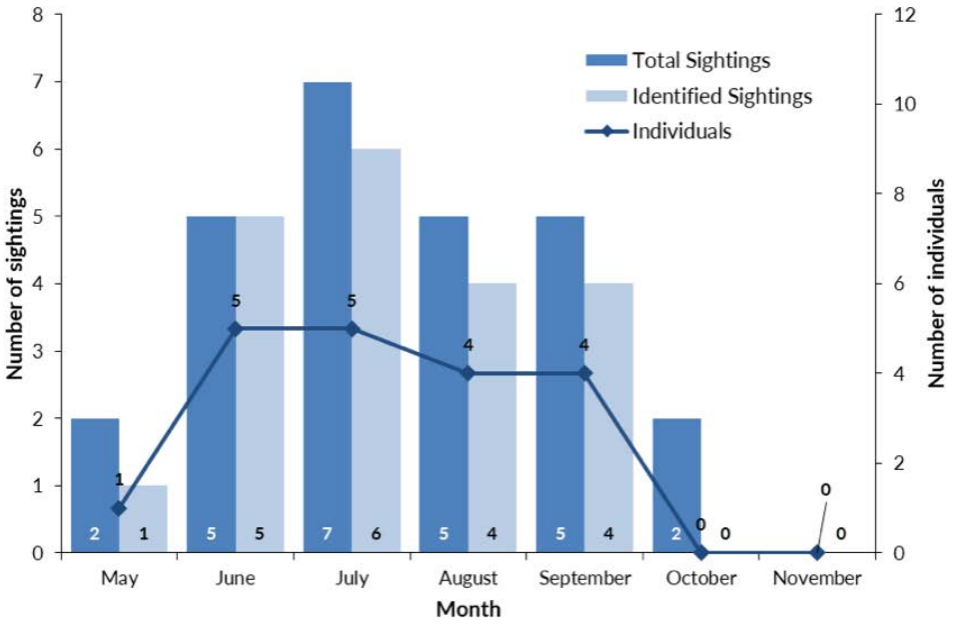


Figure 16: Whale shark (*Rhincodon typus*) sightings (total and identified) recorded by the MMCP in Baa Atoll during 2024, and the total number of individuals recorded during each month of intesive surveying.

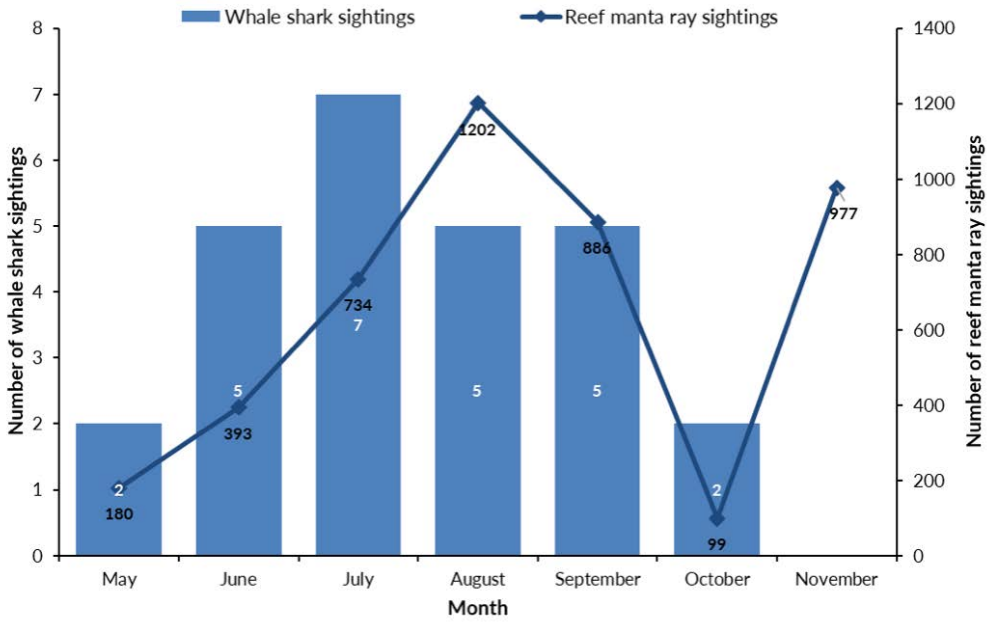


Figure 17: Monthly whale shark (*Rhincodon typus*) and reef manta ray (*Mobula alfredi*) sightings recorded at Hanifaru Bay, Baa Atoll in 2024.

POPULATION SIZE & DEMOGRAPHICS

The total number of individual reef manta rays recorded in Baa Atoll since data collection began in 1992 is 2,556, almost half (42%) of the Maldives reef manta ray population recorded to date (*n*=6,096). As of 2024, population demographics of Baa Atoll constitute 53% females (*n*=1,352), 46% males (*n*=1,177) and 1% individuals for which the sex could not be determined (*n*=27). The population comprises 1,541 adults, 1,008 juveniles, and seven individuals of unknown maturity status. Of the manta rays recorded in Baa Atoll (*n*=2,556), 49% (*n*=1,246) have also been seen in at least one other atoll in the Maldives: spanning from the very northern atoll of Ihavandhippolhu, down to the southernmost atoll of Addu (Fig. 18). This highlights the importance of Baa Atoll as a core aggregation site for the Maldives manta ray population during the Southwest Monsoon.

Throughout 2024, a total of 398 adult and 264 juvenile reef manta rays were sighted, as well as one individual for which maturity status could not be determined. This included 350 females, 299 males, and 14 individuals for which sex could not be determined. Maturation was defined by the presence of dorsal or ventral mating scars/wounds, visible pregnancies, or an estimated disc width of > 320 cm in females, and by the enlargement and calcification of claspers in males. All other individuals were classified as juveniles.

In the main sampling period (May to November), adult females accounted for the largest proportion of reef manta ray sightings in every month except October (49% overall, *n*=2,169), followed by adult males (21% overall, *n*=935) (Fig. 19). For juvenile manta rays, accounting for 31% (*n*=1,365) of sightings during these months, there was an even more pronounced skew towards females (22% overall, *n*=992), while juvenile (including subadult) males accounted for just 8% (*n*=343). The only month which did not follow this general pattern was October, likely owing to the uncharacteristically low number of sightings recorded (*n*=99). These figures highlight the importance of Baa Atoll for sexually mature and reproductive females, which is likely to be driven by the high abundance of zooplankton trapped at Hanifaru Bay and other feeding sites during the Southwest Monsoon. Indeed, of the 2,169 sightings of adult females recorded between May and November, 92% (*n*=2,016) were recorded engaging in feeding behaviour at sites throughout Baa Atoll, with Hanifaru Bay accounting for the majority of these (*n*=1,762).

A total of 226 new individual reef manta rays were documented across the Maldives during 2024, a population increase of approximately 4% from the previous year (2023, *n*=5,870), bringing the total Maldives population to 6,096. Of these new individuals added to the MMCP database in 2024, 23% (*n*=53) were documented in Baa Atoll, similar to the previous year (2023, *n*=52) (Fig. 20). Of the 53 new manta rays sighted in Baa in 2024, 4% were adult manta rays (*n*=2), 94% were juveniles (*n*=50), and 2% were of unknown maturity (*n*=1). Of these individuals, 51 were first identified in Baa Atoll, while the other two were first identified in other atolls but later sighted in Baa Atoll. While the number of newly identified manta ray individuals remained at a similar number during 2024, there is a general downward trend of the proportion of newly sighted individuals throughout study years (Fig. 20). As more data is collected over the years by MMCP, the number of new individuals (especially adults) becomes less frequent, suggesting that most of the Baa Atoll (and indeed the Maldives) reef manta ray population has been recorded and identified.

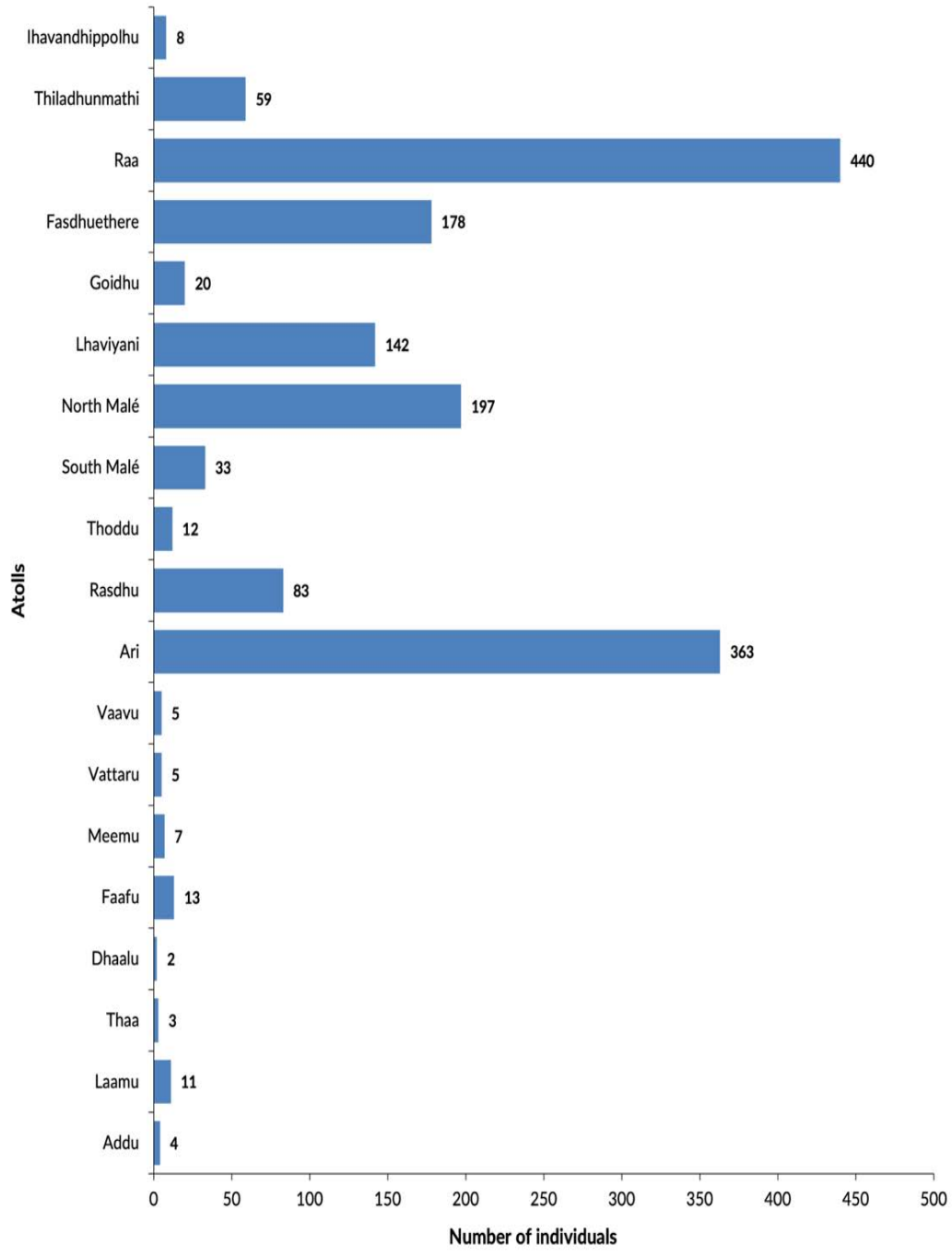


Figure 18: Number of reef manta ray (*Mobula alfredi*) individuals (*n*=1,246) from among the Baa Atoll population (*n*=2,556) which have been recorded in other atolls throughout the Maldives Archipelago.
** Many of these cross-atoll individuals have been observed in more than two atolls.*

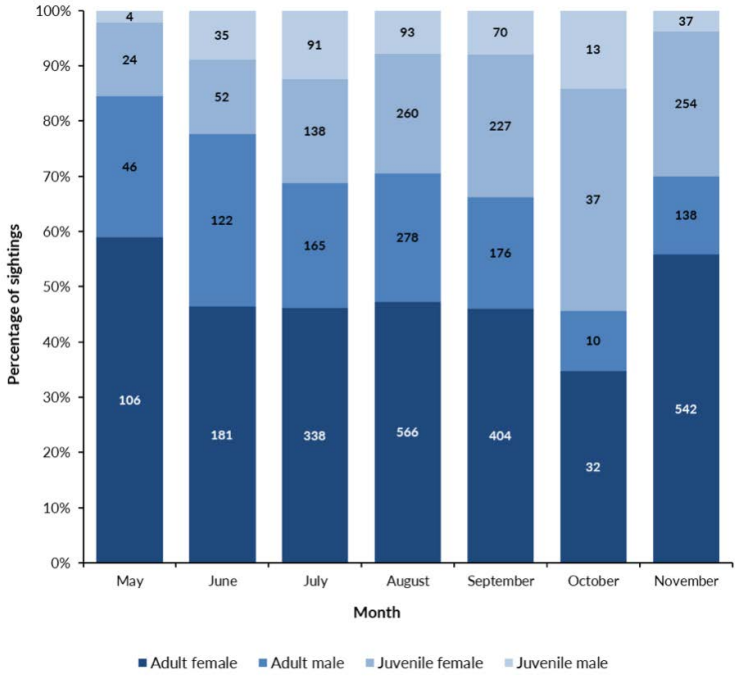


Figure 19: Reef manta ray (*Mobula alfredi*) sightings distribution categorised by maturity status during each month of intensive surveying effort in Baa Atoll in 2024. *Actual numbers within bars.*

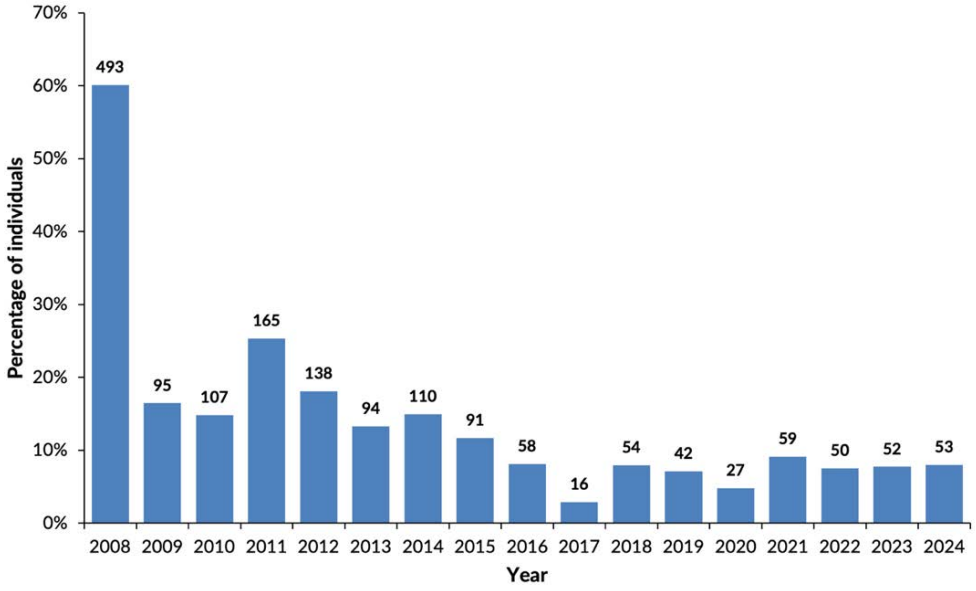


Figure 20: Proportion of the total reef manta rays (*Mobula alfredi*) sighted annually in Baa Atoll which were newly sighted individuals (2008 to 2024). *Actual number of new individuals above bars.*

REPRODUCTIVE ACTIVITY

This report marks the twelfth year in a row that the MMCP has recorded pregnancies among the Maldives reef manta ray population. A total of 13 individuals were recorded as pregnant in Baa Atoll in 2024, 7% of all adult females sighted in the atoll that year (*n*=188). The number of pregnancies recorded in 2024 was a decrease from the previous year (2023, *n*=54) (Fig. 21). The gestation period of manta rays is a little over one year, and pregnancies become visible to researchers at about 4 to 6 months (2nd trimester onward). Of the 13 pregnant females observed in Ball Atoll during 2024, 62% (*n*=8) were in the later stages of gestation (3rd or 4th trimester) when first sighted. A further eight females were recorded with fresh reproductive wounds but were not recorded as pregnant. Courtship behaviour was observed during seven surveys during the Southwest Monsoon (June: *n*=2; July: *n*=1; September: *n*=1; October: *n*=2; November, *n*=1), which occurred at Hanifaru Bay (*n*=6), and Dharavandhoo Corner (*n*=1).

The relatively low number of pregnancies recorded in 2024 highlights the need to continue and increase the protection of the species and its habitats in a changing environment. Overall, manta rays display slow reproductive rates, with, on average, only 14% of the mature females sighted in Baa Atoll annually being recorded as pregnant. With such low fecundity it becomes vital for the survival of these animals to minimise anthropogenic and natural impacts. Effective measures include the establishment of functional MPAs and the adherence to sustainable tourism activities at key manta ray mating, cleaning, and feeding sites.

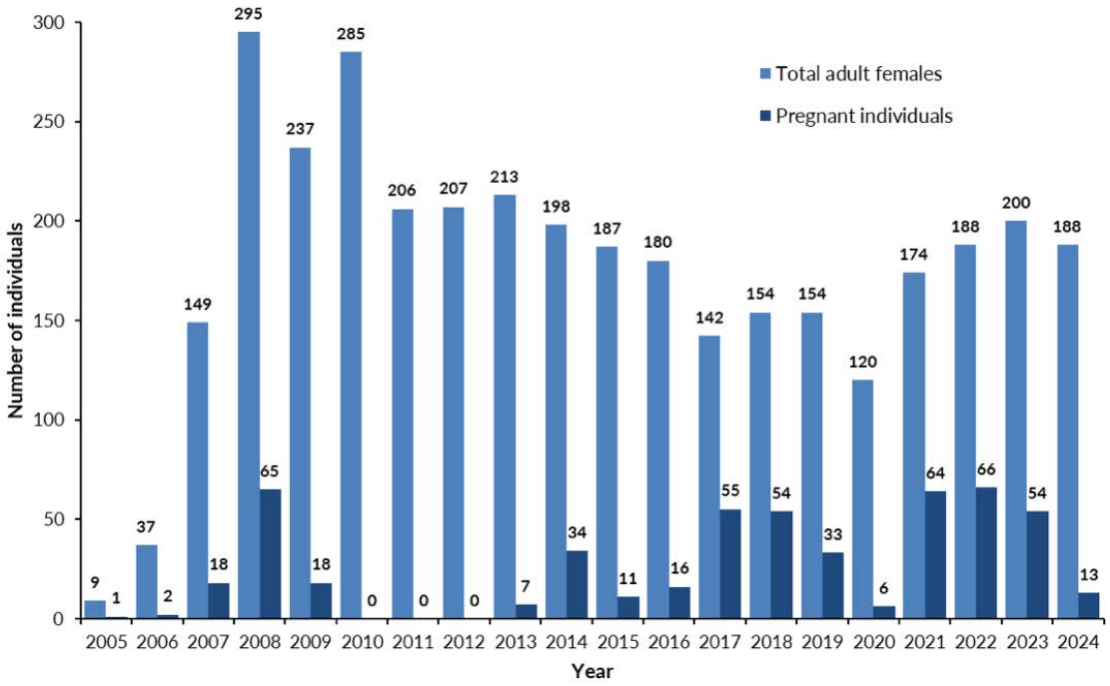


Figure 21: Number of adult female reef manta ray (*Mobula alfredi*) individuals sighted annually in Baa Atoll from 2005 to 2024, and the number of those females which were recorded as being pregnant in the same year. *Actual numbers above bars.*

SUB-LETHAL INJURIES

A total of 36 new sub-lethal injury events were recorded among reef manta rays in Baa Atoll in 2024 (Fig. 22), affecting 35 different individuals. Of these injuries, 42% (*n*=15) originated anthropogenically, 42% (*n*=15) originated naturally, and 17% (n=6) were caused by an undetermined source. Anthropogenic injury types included fishing line entanglement (*n*=11), boat strike (*n*=3), and rope entanglement (*n*=1), while natural injuries were attributed to predatory bites (n=11), infection, disease, or parasites (*n*=3), and deformity (*n*=1). Of the injuries observed in 2024, 58% affected the pectoral region of the animal (*n*=23) (Fig. 23), which in severe cases could impair a manta ray's swimming efficiency or ability to evade predators.

Although manta rays have shown resilience to a range of sub-lethal injuries, the continued increase in boat traffic, tourism, and fishing activities in the region will likely lead to more frequent injuries, particularly in sheltered lagoonal areas where manta ray habitat and human activities overlap. Despite being protected nationally in the Maldives and having never been targeted by a commercial fishery in the region, incidental bycatch and marine traffic still present a considerable threat. The long term implications of sublethal injuries for the health and fitness of these animals are unclear.

Of the anthropogenic threats, entanglement in fishing line (*n*=11) was the most common sublethal injury type affecting the Baa Atoll manta ray population (Fig. 22). This total does not include an additional 12 instances of fishing lines and hooks becoming embedded in the animal's skin, as such injuries do not often cause permanent scarring or damage; instead, the hook usually falls out naturally leaving little to no scarring. Although causing only superficial wounds, predominantly around the head, mouth, and gill area, these injuries serve as clear markers of interactions with fishing gear. When combined, sub-lethal and superficial fishing gear interactions reach a total of 23 for 2024 which highlights an area where management should be improved to protect the species in this region. Of additional concern is the continued occurrence of boat strike injuries, which have been recorded for 12 individuals in Baa Atoll since 2020. This serves as a reminder that slow speed zones should be respected and followed by all vessel operators to avoid these potentially lethal events from occurring.

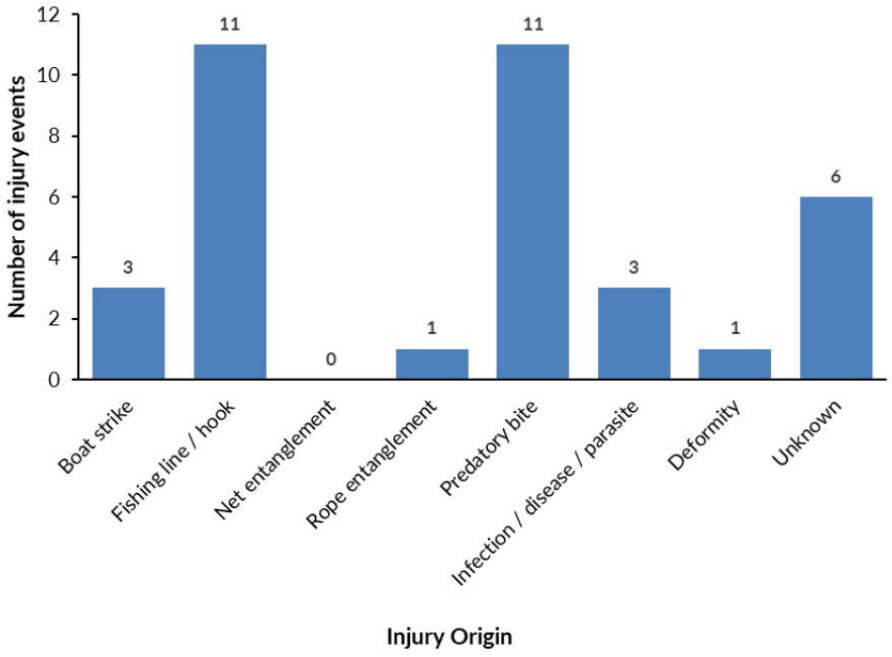


Figure 22: Variations in the likely origin of sublethal injury events (*n*=36) among the reef manta rays (*Mobula alfredi*) recorded injured in Baa Atoll in 2024.

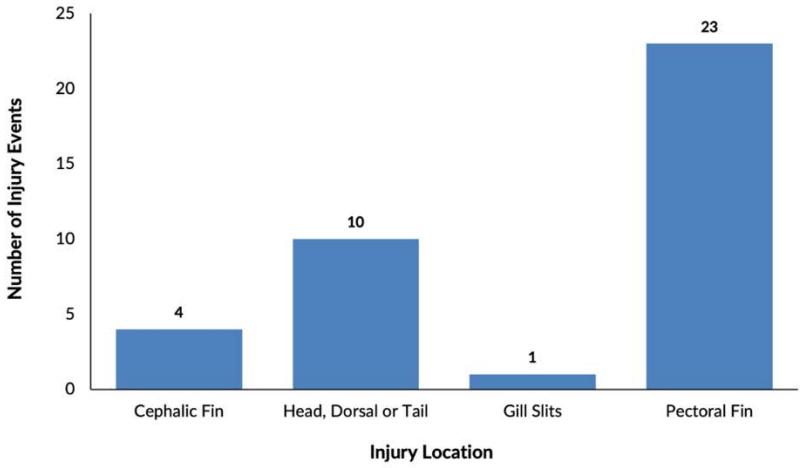


Figure 23: Variations in the locations (by body part) of sublethal injuries (*n*=40) among the reef manta rays (*Mobula alfredi*) recorded injured in Baa Atoll in 2024. *Actual number of injuries on bars. Note that injury events can affect multiple parts of the body.*

ADDITIONAL RESEARCH

Oceanography - Oceanic Drivers of Reef Manta Ray Behaviour Within Baa Atoll

The long-term oceanography study is being conducted in collaboration with University of Plymouth, the Maldives Environmental Protection Agency, the Garfield Weston Foundation, and the Bertarelli Foundation, with cooperation and support from the Biosphere Reserve Office and Four Seasons Resort at Landaa Giraavaru. The project aims to determine the drivers for spatiotemporal changes in the availability and density of zooplankton throughout Baa Atoll, and the corresponding response in the resident reef manta ray population.

In February and August 2024, the MMCP team assisted Dr. Phil Hosegood from the University of Plymouth (UK) to retrieve, maintain, and redeploy oceanographic moorings within Hanifaru Bay MPA and the surrounding waters of Baa Atoll to monitor the evolution of currents, water properties, and zooplankton abundance. Working with Dr. Hosegood and visiting research assistants from the University of Plymouth since August 2022, the MMCP team have deployed numerous oceanographic sensors (Nortek Signature 1000 Acoustic Doppler Current Profilers) in and around Hanifaru Bay MPA. Deep moorings were deployed bi-annually in Dharavandhoo Channel at 38 to 39 m (Signature 500 and Thermistor String), and in the Channel close to Landaa Giraavaru at a depth of 50 m (Aquadopp and Thermistor String), with the latest deployments to be retrieved and redeployed in February 2025. In addition, MMCP researchers used a CTD (Conductivity, Temperature, Depth) instrument to study the Deep Chlorophyll Maximum, a layer of high phytoplankton concentration found at certain depths. The instrument was deployed to two different depth profiles, inside the atoll (40 to 45 m) and outside the atoll (70 to 80 m).

This long-term study will vastly improve our understanding of how Hanifaru Bay functions, and, in turn, how it influences the aggregative behaviour of manta rays, and indeed other megafauna, within this critical habitat. Observations from this project are already providing a significant insight into the dynamic regime over Baa Atoll, which could provide the oceanographic knowledge for further assessments throughout the region. The success of these observations and modelling approach, combined with observations of manta ray behaviours by the MMCP over the past 20 years, are changing our understanding of how tropical ecosystems function. Future plans include continuing the current work for a third and final year during 2025 to cover warming due to climate change, but also the observed impacts of El Niño during 2024. A similar approach will be extended to Raa Atoll during 2025, with a particular focus on Maamunagau Falhu.

Ears on the Reef - Acoustic Impact of Human Activities on Manta Rays

Master's students from the University of Bristol are leading the Ears on the Reef project: the first acoustic study of manta ray feeding and cleaning stations in the Maldives. This work will investigate both natural and anthropogenic influences on manta ray feeding and cleaning activities within Hanifaru Bay, and nearby cleaning stations in Baa Atoll, with a focus on understanding the acoustic impact of human activities. The project integrates three interconnected components: acoustic soundscape exploration, sustainable tourism practices, and the assessment of human sound pollution. The soundscapes of these ecologically important ecosystems are previously unexplored and will allow us to better understand the drivers and limiters of ecosystem health and thus improve and inform conservation strategies for the management of the Hanifaru Bay MPA. The study aims to investigate how the soundscape changes before and after boat presence and how this affects manta presence and cleaner client interactions or manta ray feeding dynamics within the area.

During 2024, underwater acoustic recording devices (hydromoths) were deployed via freediving at seven different sites in eastern Baa Atoll, including Hanifaru Bay MPA. Hydromoths were deployed every 5 to 6 days to account for device battery life. To complement the acoustic recordings, remote underwater video and photo surveillance (RUV / RUP) was conducted using one GoPro camera or Insta-360 camera attached to a dive weight at each of the cleaning stations. These cameras were used to capture manta ray presence, abundance, and behaviour, along with cleaner fish communication patterns, cleaning station activity, and human interactions to match the acoustic data with visual. To measure the ecology and health of the reef, coral cover and fish surveys were conducted via scuba diving using a 50 cm² quadrat and a transect line respectively. A total of 15 coral surveys and 15 fish surveys were conducted, with each site being surveyed a minimum of two times for ecological validity.

The project's long-term goals include understanding the development of cleaning station soundscapes, mitigating negative impacts of human sound pollution, and preserving the health and biodiversity of manta ray cleaning stations. Baseline data from the study will inform the development of conservation measures. Furthermore, the study aims to provide a holistic approach that enhances our understanding of the complex dynamics at manta ray cleaning stations and promotes their conservation while encouraging responsible tourism practices in and around cleaning stations in Baa Atoll. The results of this work will also be integrated as a comparative study site assessment for the larger complementary work conducted in Laamu, Raa and Baa Atolls.

Marine Education Programme Effectiveness Study

During 2024, MMCP Research Intern, Mia McAllister, conducted a study evaluating the effectiveness of the MMCP's Moodhu Madharusaa MEP delivered between 2018 – 2024 to five schools in the Maldives, four of which were in Baa Atoll. Using pre- and post-programme surveys, differences in students' responses/scores for attitude, behaviour, knowledge, and engagement towards the marine environment were investigated across the five schools and 163 students aged 12 to 15 (grade 7 to 10). Key findings included students' attitude, behaviour, and knowledge towards the marine environment improved after the MEP compared to before; male students had a less favourable attitude towards the environment than females; and students in higher school grades had more favourable attitudes than those in lower grades. These positive results may support a young generation of conservation-aware individuals, equipped with the knowledge and tools to take stewardship of their environment; inspire intergenerational change in their communities; and pursue conservation-based careers.

TOURISM ACTIVITIES

Manta rays are very sensitive to disturbance, and if left without proper measures, tourism has the potential to do more harm than good. This Best Practice Code of Conduct for manta ray tourism has been formed based on years of research. These guidelines explain how divers and snorkellers should interact with these animals in-water to enhance their experience and ensure their presence has the least impact on individual manta rays.

Throughout 2024, the MMCP strove to improve the sustainability of manta ray tourism activities in Baa Atoll by encouraging tour operators to voluntarily sign up as a "How to Swim with Mantas" operator. In doing so, these operators were provided with resources to support and assist dive guides, snorkel guides and boat teams to lead sustainable manta ray watching tours.

Beyond education of marine users, it is crucial to the conservation of the Maldives manta ray population that there is improved monitoring of diver and snorkeller manta ray tourism activities, including boat speeds linked to these activities, at manta sites and other protected areas throughout Baa Atoll. Rules and regulations within Hanifaru Bay aid in the protection of these animals. However, these measures (or similar) should be implemented at other key manta ray aggregation sites in Baa Atoll and throughout the country. It is crucial the tourist community understand the importance of safe boating and in water best practices.

CONSERVATION MANAGEMENT

Baa Atoll has been globally recognised as one of ~700 UNESCO World Biosphere Reserves around the globe, in part because of its ecological importance as an aggregation site for manta rays and whale sharks. As such, this region is an extremely important research location for these species globally. The designation of Hanifaru MPA as a core zone within the reserve is extremely important for the conservation of the Maldives manta ray population. Therefore, this location needs continued protection and effective management practices. We look forward to future partnerships and commitments with the Maldives' Environmental Protection Agency and the Baa Atoll Biosphere Reserve Office to protect this world-renowned site.

Research within Baa Atoll's UNESCO World Biosphere Reserve must remain a top priority for all involved. Biosphere reserves help us to better understand population dynamics, conservation and management strategies, conflict prevention, and human impacts on certain species. The consistent quality of the long-term data collected within Baa Atoll allows us to gain a deeper knowledge of manta rays worldwide. Continued access to monitor these animals and how this critical habitat functions to support them is imperative to our research goals and further advancement as the leading manta ray research programme in the world.

Following the groundwork set by the 2012 government management plan, sustainable tourism practices and strict regulations are continuously being enforced within the Hanifaru MPA. These include but are not limited to: tourist and boat limits, SCUBA and fishing bans, scheduled alternation of entrance days between liveaboards and resort boats, speed limits, and specified use of entrance and exit routes. To be qualified as a Hanifaru Bay guide, and therefore escort guest tours inside the MPA, the guide must first pass an exam. Furthermore, all guides are required to hold first aid and divemaster qualifications, at a minimum, before qualifying as a Hanifaru Bay guide.

In 2024, Baa Atoll Biosphere Reserve rangers were again on site to maintain the rules and regulations of Hanifaru Bay MPA. This act has resulted in a decrease of infractions and a well-maintained schedule of alternating tourism days. Such regulations and management initiatives are vital to ensure the efficacy of Hanifaru MPA in conserving the Maldives manta ray population, by minimizing the harmful ramifications arising from human-manta ray interactions.

During 2024, the MMCP Baa Atoll team, along with other stakeholders in Baa Atoll, continued to work with scientists from the UK-based Joint Nature Conservation Committee (JNCC) and the Centre for Environment, Fisheries, and Aquaculture (CEFAS) to advise on and review drafts of the Hanifaru MPA Research and Monitoring Plan, and associated documents, which will be completed during 2025.

BAA ATOLL MARINE EDUCATION PROGRAMME

'Moodhu Madharusaa' or 'Ocean School' is the MMRP's flagship marine education programme. Moodhu Madharusaa aims to:

- Build a conservation-aware generation that will take stewardship of their environment.
- Inspire intergenerational change in communities.
- Equip students with skills to pursue marine-based careers.
- Increase swimming and snorkelling confidence.

The MMCP, in partnership with the Ministry of Education, delivers a six-month Moodhu Madharusaa programme, covering five core modules including marine ecology, coral reefs, marine megafauna, seagrass and mangroves and ecosystem conservation. The programme promotes experiential learning and prioritises field trips, including nature exploration and snorkelling, which are supported by theory lessons and practical activities. From participating in mock stakeholder conferences to establish marine protected areas, to making marine ecosystem posters and creating awareness-raising videos, homework assignments are designed to encourage intergenerational learning.

Since its inception in Baa Atoll in 2015, Moodhu Madharusaa has been expanding in reach (Fig. 24). Over 300 students from seven schools across two atolls have now completed the programme. During March – August 2024, 32 students from Kihaadhoo School in Baa Atoll completed Moodhu Madharusaa. The students completed 50 hours of theory lessons and fieldtrips (Fig. 25) and achieved a 59% pass rate in the final exam. Highlights included a manta ray snorkel at Veyofushi Falhu where all students swam with 15 manta rays, and a visit to the protected island Olhugiri in Baa Atoll to see mangrove forests, in collaboration with the Biosphere Reserve Office.

Pre- and post-programme surveys were conducted to assess the effectiveness of the programme and gain insight into the environmental knowledge students gain. The survey findings showed that students spent 16% more time snorkelling and exhibited improved marine environmental attitudes, pro-environmental behaviours, and swimming and snorkelling confidence. The B. Kihaadhoo programme's success was due to the successful collaboration between partners and the enthusiasm from Kihaadhoo School and island community.

After completion of the full six-month programme with Kihaadhoo School, the MMCP offered a shorter three-month marine education programme to B. Dhonfanu School. A total of 29 students from grades 7 to 10 completed the programme between September – November 2024. The students completed theory lessons, field trips, documentary screenings, home assignments (Fig. 26) and achieved a 65% pass rate in the final exam. Highlights included visiting the Marine Discovery Centre at Four Seasons Landaa Giraavaru, building a coral frame with Reefscapers PVT LTD, and snorkelling at Kihaadhuffaru reef where all students enjoyed seeing turtles and reef sharks. Results from the pre- and post-programme surveys conducted showed that students' marine environmental knowledge improved by 27% after completing the Moodhu Madharusaa programme. Students spent 9% more time snorkelling and exhibited improved marine environmental attitudes, pro-environmental behaviours, and swimming and snorkelling confidence.

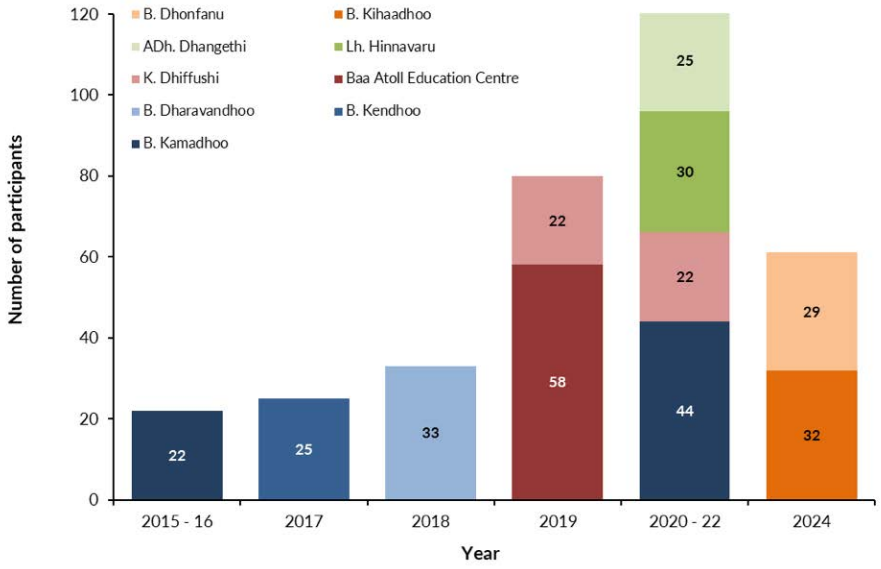


Figure 24: Number of students who completed the Moodhu Madharusaa Marine Education Programme annually on different islands in the Maldives, between 2015 to 2024.

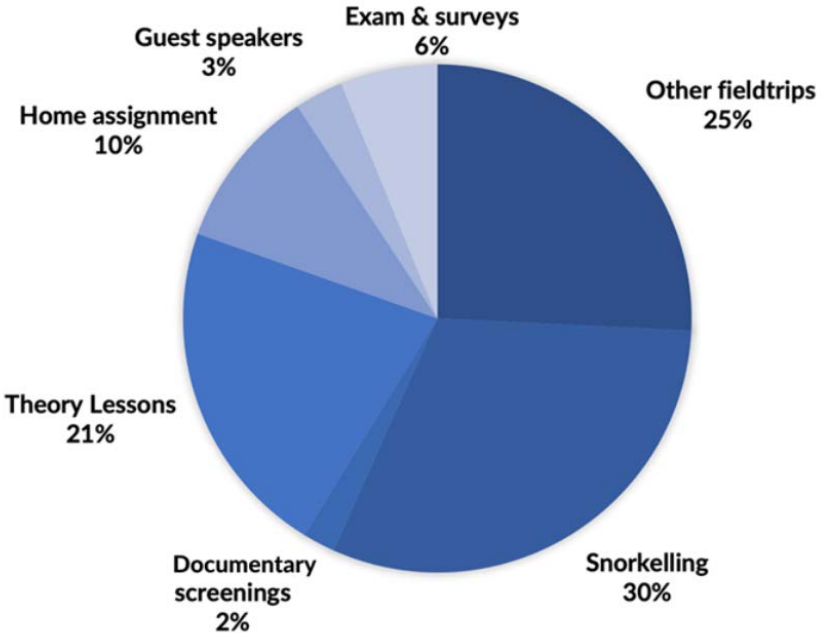


Figure 25: Percentage of time devoted to each activity comprising the Moodhu Madharusaa Marine Education Programme delivered to B. Kihaadhoo School in 2024.

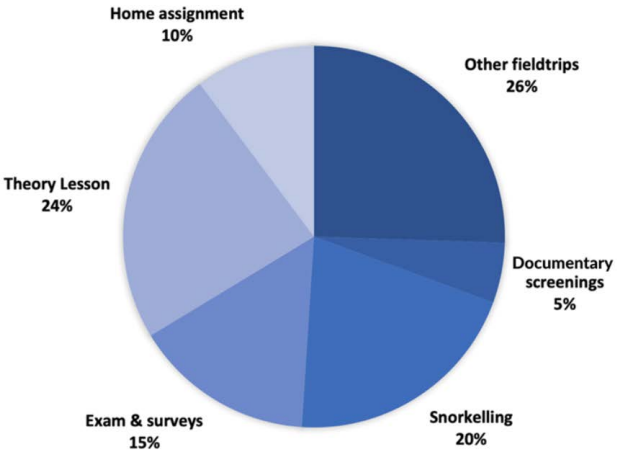


Figure 26: Percentage of time devoted to each activity comprising the Moodhu Madharusaa Marine Education Programme delivered to B. Dhonfanu School in 2024.

EDUCATION & OUTREACH ACTIVITIES

During 2024, the MMCP attended several festivals and forums held throughout the country. In February, the team attended the Maldives Marine Expo held in Hulhumalé, during which a total of 310 visitors (120 children and 190 adults) attended the MMCP stall. In July, the team attended the fifth Maldives Marine Science Symposium held at Maldives National University, where MMCP team members from other project bases in the Maldives presented key research findings. In September, the MMCP organised a "mini" manta ray festival held on Dhonfanu Island to celebrate World Manta Day. NGOs, such as Maldives Whale Shark Research Programme (MWSRP) and Reefscapers PVT LTD, along with Baa Atoll Biosphere Reserve Office and MMCP, set up stalls at the event to provide games, prizes, and information to community members. Dhonfanu Council provided support and Dhonfanu School students participated in a sand sculpture competition where winning groups were awarded prizes sponsored by The Manta Trust, Maldives Whale Shark Research Programme (MWSRP), and Baa Atoll Biosphere Reserve Office. The MMCP team also travelled to Lh. Naifaru in October for the 2 day Turtle Festival and Marine Symposium organised by the Atoll Marine Centre and joined by exhibitors from other marine conservation NGOs, schools and community members. A total of 104 visitors attended the stall and 50 visitors attended a Research and Outreach presentation delivered by the MMCP. The MMCP team also delivered presentations which cover manta biology and research techniques to students from Dharumavantha School in Malé City on their trip to the Baa Atoll Biosphere Reserve, a school from Fuvahmulah, and Ajfan International Academy badminton team. These field trips were organised and led by the Baa Atoll Biosphere Reserve Office team. In addition to school presentations, the team took part in 'Kandugathering' session which is a series of educational sessions organised by Ocean Warriors Dive Centre in Malé City. A total of 15 attendees took part in the session which included a manta ray ID workshop.

In collaboration with Reefscapers PVT LTD and Four Seasons Resort at Landaa Giraavaru, the Baa Atoll Marine Biology Internship, started in 2023, was expanded in 2024 with the introduction of Stage 2, whereby six students from the initial programme were chosen for a more extensive longer-term internship. Students spent five days taking part in field work activities, which included turtle rehabilitation, coral restoration, collecting manta ray IDs, and processing survey data. An additional 24 students from all schools across Baa Atoll took part in the second annual 3-day Stage 1 Marine Biology Internship programme. This programme will continue into 2025.

MANTA STORY APP.

In collaboration with the Manta Trust's partner Four Seasons Resort at Landaa Giraavaru and Loopcraft (based in Malé), in 2023 the MMCP were proud to release the world's first manta ray-focused mobile application to the Apple App Store and Google Play Store. "Manta Story" is a documentary style educational interactive app with virtual and augmented reality features for users to experience the life, biology, and journey of reef manta rays in the Maldives. In 2024, the app was updated to include an educational 'fact-file' section detailing the global threats to manta rays. Animated illustrations demonstrate the impact of these threats on individuals and manta ray populations worldwide.

This report was made possible thanks to

MALDIVES GOVERMENT AUTHORITIES

The Manta Trust is grateful for the opportunities provided by the Ministry of Environment and Energy, the Ministry of Fisheries, Marine Resources and Agriculture, the Environmental Protection Agency, and the Marine Research Centre. All data was collected in accordance with the relevant permit requirements of the aforementioned governing bodies.

The Manta Trust would also like to extend a warm thank you to all the other resorts, guest houses, liveaboards, dive centres and watersports teams as well as the marine biologists and citizen scientists who have supported our research and submitted sightings.

We thank the Maldives Government for granting us permission to undertake this research and we thank the Baa Atoll Biosphere Reserve Office for their continued support with field work activities and community outreach initiatives. Special thanks to Manta Trust's resort partner Four Seasons Resort Maldives at Landaa Giraavaru. We thank all Manta Trust staff, students, and volunteers in the Maldives as well as the marine biologists, water sports and dive teams in Baa Atoll who contributed huge amounts of photo-ID data used in this report. Finally, we would like to thank all the members of the public who submitted images to the Manta Trust during 2024.

MALDIVES MANTA
CONSERVATION
PROGRAMME

MALDIVES MANTA CONSERVATION PROGRAMME (MMCP)

The Maldives is home to the largest photo-identified population of reef manta rays in the world and the MMCP is privileged to oversee one of the longest running research programs on this species in the world. Numerous advancements on the understanding of the ecology, reproductive biology, and behaviour of reef manta rays have been made based on research conducted or facilitated by the MMCP. We welcome continued collaboration with the Maldivian government for the long-term conservation and management of this incredibly charismatic marine species.

The MMCP and the Manta Trust are happy to share with the government data collected as a part of this study. For further information or please email: baa@mantatrust.org or mmcpteam@mantatrust.org.

The opportunities that the Manta Trust's MMCP have in the Maldives are unparalleled. Working in an area that is home to the largest aggregation of reef manta rays in the world, our research continues to expand every year. We are humbled by the thought of being able to further pursue our research programmes alongside the Maldives government. The opportunity we have to learn about manta rays in the Maldives is unique and has many implications on a global scale for manta ray conservation.

Manta TRUST

MALDIVES MANTA CONSERVATION PROGRAMME

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